CREDIBILITY ASSESSMENT AND EVALUATION OF THE ASTRONAUT MUSCULOSKELETAL BOOT/ANKLE INJURY SCENARIO USING OPENSIM™ COMPUTATIONAL MODELING

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INTRODUCTION

- The musculoskeletal system of astronauts is subject to physiological changes from exposure to different gravitational environments experienced during spaceflight.
- Injuries can occur while an astronaut is performing an extravehicular activity (EVA) in space, on lunar or planetary surfaces, or while wearing a spacesuit during terrestrial training for an EVA.
- One area of concern includes injuries to the ankles which may occur due to a poorly fitting spacesuit boot not supporting the ankles sufficiently. This can cause the astronaut to twist an ankle and stretch the ligaments resulting in an ankle sprain during an EVA.
- The OpenSim software can model the EVA activities that lead to musculoskeletal injuries such as muscle strain or joint injuries and the results are then compared to injury thresholds.

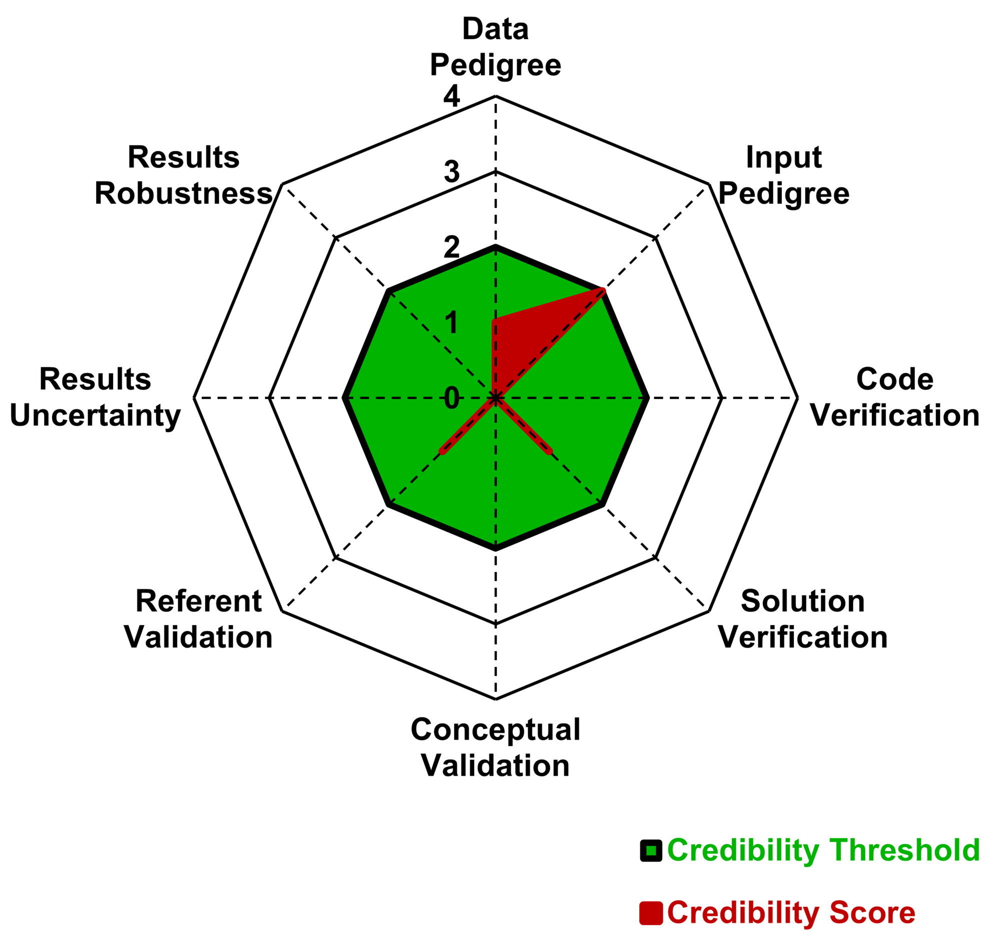
METHODS

- The credibility assessment was performed per NASA-STD-7009A [1] to evaluate OpenSim [2] musculoskeletal modeling for boot/ankle injuries.
- Existing OpenSim models were evaluated based on their capabilities in the analysis of ligament injury per the eight credibility factors below.
- The resulting credibility scores are shown next to each factor and on the adjacent radar plot.

Data Pedigree (1)
Input Pedigree (2)
Code Verification (0)
Solution Verification (1)
Conceptual Validation (0)
Referent Validation (1)
Results Uncertainty (0)
Results Robustness (0)

CREDIBILITY FACTOR SCORES

- The threshold for the boot/ankle injury credibility analysis score is set at 2 out of 4 for all factors.
- The project defined threshold score of 2 - per guidance from NASA EVA subject matter experts - should be achievable for the assessed models after the improvements are performed.



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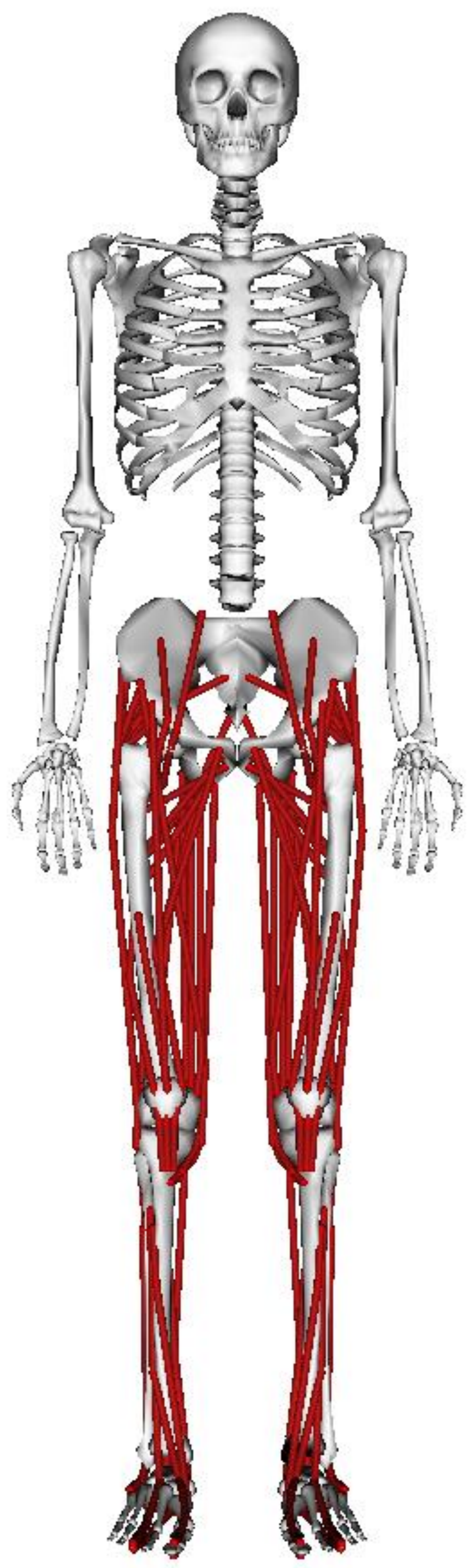
RESULTS

- The credibility assessment of the OpenSim models, when used in a boot/ankle ligament injury analysis, resulted in credibility scores between 0 and 2, on a scale of 0 to 4.
  - A score of 4 identifies all necessary information and data for real-world EVA scenarios.
  - A score of 0 implies there is insufficient evidence to draw any conclusions.
- The evaluated knee model is a detailed ligament model of just one knee and the ligaments would need to be incorporated into a full body model for a meaningful EVA analysis.
- Adding ligaments to the desired joints is one proposed model improvement in simulating the space suit's effect on joint movements of the model.

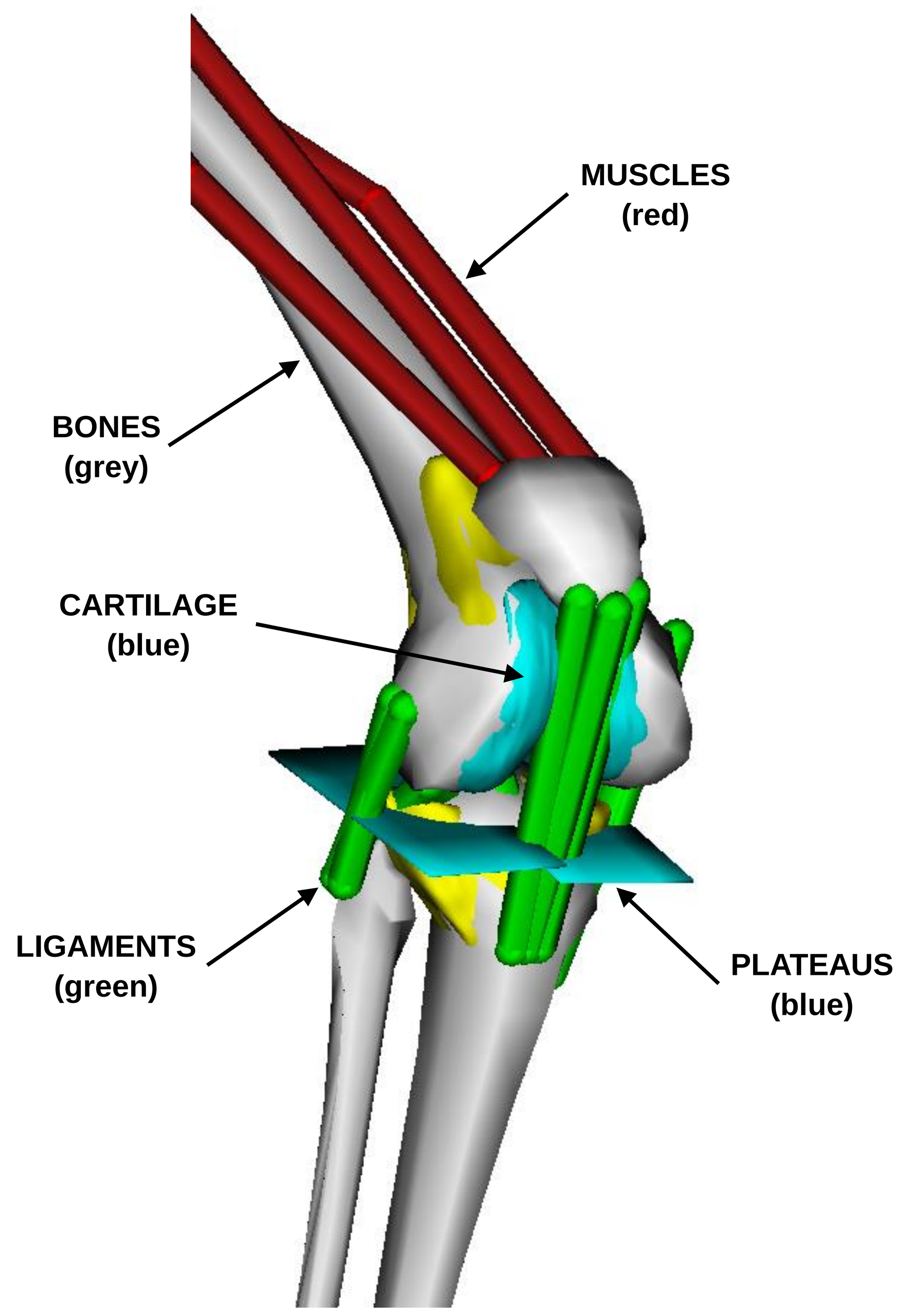
FULL BODY OPENSIM MODEL

- The Full Body Model [3] was analyzed in this credibility analysis. The model has lower body muscles at the ankles but no ligaments.



DISCRETE ELEMENT KNEE MODEL

- The Discrete Element Knee Model [4] was also analyzed. This is a model of just the right knee that includes the 18 knee ligament bundles.
- The model also includes the femur cartilage and plateaus between the femur and tibia for calculation of medial and lateral contact forces.



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